



ExLog Group

Littoral Combat and Power Projection FNC

Strike-Up/Strike-Down Base Period Summary





Table of Contents

Summary	1
1) Omni-Directional Vehicle	2
2) Linear Electric Drive Transport	3
3) Hybrid Linear Actuator	4
4) Human Amplification (HAT)	5
5) Advanced Weapons Elevator	6
6) Universal Loading Tray	7
7) Sensor Based Dynamic Manipulation	8
8) NAVSTORS Components	9
9) Automated Stowage and Retrieval System	10
10) Blast Resistant Containers	11

Summary

The ExLog Group of the Littoral Combat and Power Projection FNC released a BAA (01-025) in June of 2001 for Shipboard Internal Cargo Strike-Up/Strike-Down. A total of ten awards were let against this BAA. Each of the efforts was funded in a base period to approximately \$300,000. The acquisition strategy was to fund a broad base of technologies at a low level in an effort to assess the technologies in a developmental environment. As a result of the acquisition strategy and the low level of funding, the base period efforts on the whole did not result in robust demonstrations of integrated equipment. The ten technologies funded were:

- 1. <u>Omni-Directional Vehicle</u> Yellow gear that can instantaneously move in any direction. An auto-guidance system for autonomous operations was proposed.
- 2. <u>Linear Electric Drive Transport</u> Cargo movement system using linear motors to allow cargo to automatically transition between vertical and horizontal movement.
- 3. <u>Hybrid Linear Actuator</u> Combined magnetostrictive actuator and linear motor for good power density electric replacement of hydraulic cylinders.
- 4. <u>Human Amplification Technology (HAT)</u> Cargo/weapons handing device to allow a single sailor to lift and precisely position a heavy load using motion compensation control on the lifter feedback. It would also create an omni-directional transporter.
- 5. <u>Advanced Weapons Elevator</u> Electrically actuated rack and pinion elevator that removes the need for elevator ropes allowing it to operate beneath a closed ballistic hatch. A highly dexterous mobile elevator carriage was proposed.
- 6. <u>Universal Loading Tray</u> A standard load handling platform for cargo and weapons movement with self-locking devices on its top surface and self-locking handling devices at the corners.
- 7. <u>Sensor Based Dynamic Manipulation</u> Control system for robotic arm manipulation that integrates continuous visual sensing with robotic manipulation, this allows a robotic arm to grab and manipulate a randomly moving object.
- 8. <u>NAVSTORS Components</u> Developing two high risk components for the ongoing NAVSTORS automated magazine SBIR. Standard Payload Interfaces (SPI) provide common grasping interface and automatically secure cargo for transit. Payload Carriers are powered, robotic sleds that automatically move loads around the magazine.
- 9. <u>Automated Stowage and Retrieval System</u> Marinization of an existing COTS technology ASRS to automate storerooms, holds and magazines and would allow for selective offload of pallets. Loads would automatically be locked into stowage during Strike-Down and unlocked for Strike-Up.
- 10. <u>Blast Resistant Containers</u> Lightweight composite material and manufacturing processes for new generation ordnance containers to contain the effects of accidental ignition of their contents.

TECHNOLOGY: OMNI-DIRECTIONAL VEHICLE

<u>Description</u>: An omni-directional vehicle combined with a forklift type operation. The vehicle is capable of motion in any direction and can rotate within its own footprint. A commercial version is currently being marketed by Airtrax, Inc. It would have an intelligent control and navigation system that allows it to autonomously travel between deck stations and a hold while avoiding obstacles.

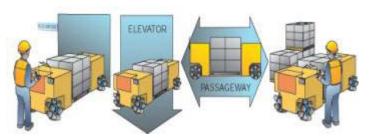
Team:

- General Dynamics Armament and Technical Products
- Airtrax, Inc.
- Orbital Research, Inc.
- Lockheed Martin Naval Electronics and Surveillance Systems Surface Systems
- NAVSEA Philadelphia, Code 977

<u>Deliverables</u>: The key deliverable was a final report that describes the utility of the equipment and a strategy for the development of the navigation and control systems.

<u>Demonstrations</u>: An RF controlled version of the vehicle was demonstrated in a parking lot and the control of the vehicle was acceptable. A non-physics-based simulation of the application of such a vehicle in combination with other cargo handling advancements was developed.

<u>Future Efforts</u>: The key future effort for this technology would be to develop and demonstrate the autonomous operation and sensor suite for the vehicle.



Autonomous Operations



Test Vehicle



Omni-Motion in Any Direction

TECHNOLOGY: LINEAR ELECTRIC DRIVE TRANSPORT

<u>Description</u>: A horizontal/vertical cargo movement system powered by Linear Motor technology. This is an extension of a previous SBIR. Technology development includes a prime mover, breaking and control system for the conveyor. The system allows automatic transition between horizontal and vertical movements. The system would be able to initiate horizontal movement at different vertical levels of a multi-level hold, or it could operate in a continuous loop.

Team:

- General Dynamics Armament and Technical Products
- Power Superconductor Applications Corp.
- Unidynamics, Inc.
- NAVSEA Philadelphia, Code 977

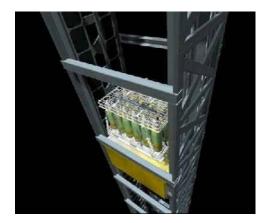
<u>Deliverables</u>: The key deliverable was a final report that describes the utility of the equipment and a strategy for the development of the future efforts. A key finding of the effort was that linear synchronous motors would be required vice linear induction motors.

<u>Demonstrations</u>: A 400 lb capacity system was successfully demonstrated at Electric Boat's Quonsett Point facility. The load carriage successfully transitioned between horizontal and vertical movement. A non-physics-based simulation of the application of such a vehicle in combination with other cargo handling advancements was developed.

<u>Future Efforts</u>: Future efforts would be used to extend the capacity of the system from 400 lbs to 12,000 lb or more and to provide a robust demonstration of this capability. Integration of linear synchronous motors and control systems will be a key challenge.



Demonstrator



Weapons Elevator Concept

TECHNOLOGY: HYBRID LINEAR ACTUATOR

<u>Description</u>: An actuator that would combine a set of magnetostrictive thrusters with either a tubular linear induction permanent magnet synchronous motor that could replace hydraulic cylinders or electric motors in cargo handling gear. A clutch/brake mechanism as part of the actuator would be developed. The combination of magnetostrictive and linear motors provides for good power density with a longer stroke than either would provide separately.

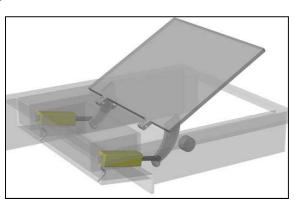
Team:

- NAVSEA Philadelphia, Code 977
- NSWC-CARDEROCK Materials Science Branch
- Temple University
- Global/SFC Valve Integrated Manufacturing

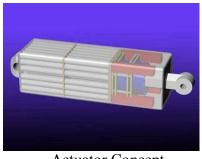
<u>Deliverables</u>: The key deliverable was a final report. The key conclusion was that a 45,000 lb force with a large stroke is feasible.

<u>Demonstrations</u>: There were no demonstrations of physical equipment. Dynamic simulations of the clutch and brake systems were performed, along with Finite Element analysis for magnetic flux and structural deformations under loaded conditions.

<u>Future Efforts</u>: The key future effort for this technology would be to fabricate a breadboard actuator and to conduct physical testing to verify performance.



Potential Application



Actuator Concept

Technology: Human Amplification Technology (HAT)

<u>Description</u>: A family of highly steerable vehicles with HAT handling devices of differing capacities. HAT provides a scalable strength assist with force feedback so that the operator retains perception of the load. The system would compensate for ship motions by removing the seaway induced loads from the feedback loop so that the operator will only "feel" the load. The vehicles would be functionally omni-directional using conventional wheels with tires and would be push/pull propelled.

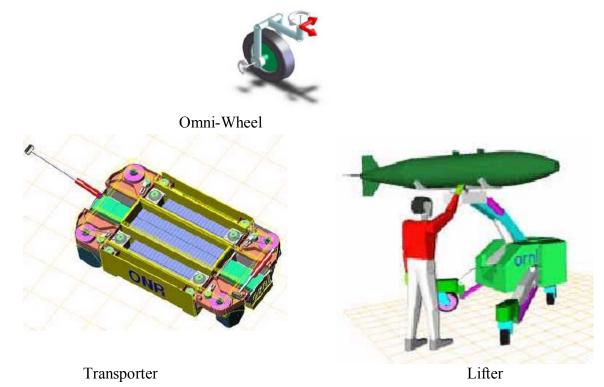
Team:

- Oak Ridge National Laboratory
- Newport News Shipbuilding

<u>Deliverables</u>: The key deliverable was a final brief that describes the details of the control algorithms for the transporter wheels and for the ship motion control force compensation.

<u>Demonstrations</u>: All demonstrations were virtual. High fidelity simulations of the transporter and of the lifter were used to validate performance. The lifter significantly reduced force feedback from seaway motions. The transporter remained under control when only 2 of the 4 wheels were in contact.

<u>Future Efforts</u>: The key future effort for this technology would be to build and test breadboard transporter and lifter units. A transporter proof of principle would be built and tested. The motion compensation would be tested on an existing 4 degree of freedom HAT machine in a ship motion simulator.



TECHNOLOGY: ADVANCED WEAPONS ELEVATOR

<u>Description</u>: A new weapons elevator for aircraft carrier-type weapons elevators would improve weapons handling rates with reduced maintenance and enhanced utilization flexibility. The primary technology is a high power density actuator with condition based maintenance built in. The system would include a new, faster ballistic hatch and a highly dexterous mobile elevator carriage.

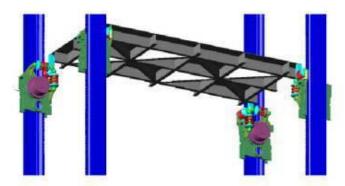
Team:

- Newport News Shipbuilding
- Virginia Consortium for Material Handling & Logistics
 - University of Texas Austin
 - Old Dominion University
 - o University of Virginia
 - Virginia Polytechnic Institute

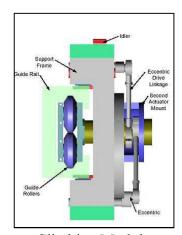
<u>Deliverables</u>: The key deliverable was a final report that describes the utility of the equipment and a concept design for a high power density actuator.

<u>Demonstrations</u>: No equipment was demonstrated. Finite element models and throughput simulations were developed in the course of the base period effort.

<u>Future Efforts</u>: The key future effort for this technology would be to build and demonstrate a quarter scale prototype of the elevator and to perform performance mapping testing on the actuators.



Elevator Schematic



Climbing Module

TECHNOLOGY: UNIVERSAL LOADING TRAY

<u>Description</u>: A standard load handling platform for cargo and weapons movement based on the removable elevator base platform proposed for the NAVSTORS program. The platform has standard self-locking devices within its top surface and self-locking devices at the corners for handling the tray. The platform will be compatible with standard 20' ISO Containers, CONREP trolleys and other advanced cargo handling gear as well as the NAVSTORS Standard Payload Interfaces.

Team:

- NAVSEA Philadelphia Code 977
- Agile Systems, Inc.
- Robotics Research Corporation
- General Tool Company
- M. Rosenblatt & Son Group of AMSEC LLC
- NSWC-IH Detachment PHS&T Center

<u>Deliverables</u>: The key deliverable was a final report that describes the results of throughput simulations. They key conclusion was that a top handler for the NAVSTORS Standard Payload Interface provided sufficient throughput and that a universal loading tray was not required.

<u>Demonstrations</u>: Throughput simulations were conducted. The SPI top handler was demonstrated at full scale.

<u>Future Efforts</u>: There are no significant future efforts for this program.



Demo of Top Handling Of Multiple Loads



Potential Applications

TECHNOLOGY: SENSOR BASED DYNAMIC MANIPULATION

<u>Description</u>: Robots can only grasp objects that are stationary or it the object's trajectory is well known. A control system for robotic arm manipulation that integrates continuous visual sensing with robotic manipulation was developed, this allows the arm to grab and manipulate the randomly moving object. Technology includes continuous multi-viewpoint shadow sensing visual technology and dynamic robotic grasp and manipulation algorithms.

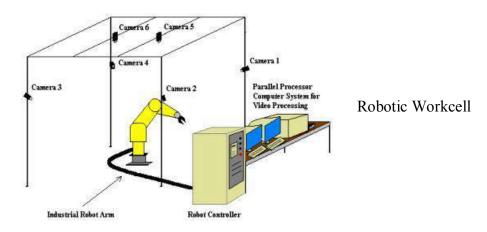
Team:

• Clemson University

<u>Deliverables</u>: The key deliverable was a series of reports that describe the algorithms and control theories underlying the technology and describes the results of the demonstrations.

<u>Demonstrations</u>: A laboratory demonstration was conducted which proved the ability of the technology to capture objects in semi-random motion. The reaction time of the robotic arm was equivalent to a human hitting a pitched baseball.

<u>Future Efforts</u>: The key future effort for this technology would be to develop and demonstrate the ability to capture an object in fully random motion in a real world environment.





TECHNOLOGY: NAVSTORS COMPONENTS

<u>Description</u>: In support of the ongoing NAVSTORS automated magazine SBIR, two high risk components - the Standard Payload Interface (SPI) and Robotic Pallet Carriers – will be developed. SPIs provide common grasping interface and secure cargo for transit. Payload Carriers are powered, robotic sleds that automatically move loads around the magazine in a slide puzzle manner in order to deliver the required load to the loading station.

Team:

- NAVSEA Philadelphia Code 977
- Agile Systems, Inc.
- Robotics Research Corporation
- General Tool Company
- M. Rosenblatt & Son Group of AMSEC LLC
- NSWC-IH Detachment PHS&T Center

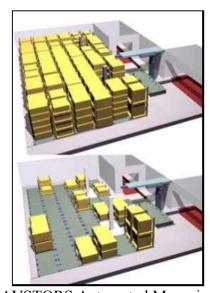
<u>Deliverables</u>: The key deliverable was a final report that describes the results of the design efforts on the SPI and their testing program.

<u>Demonstrations</u>: The SPI were successfully demonstrated on the Ship Motion Simulator at NAVSEA Philadelphia. The motion platform was set up to simulate a Nimitz Class aircraft carrier in sea state 4 through 7.

<u>Future Efforts</u>: The key future efforts for this technology would be to develop and demonstrate the robotic payload carriers on the ship motion simulators.



SPI Demonstrations on Ship Motion Simulator



NAVSTORS Automated Magazine

TECHNOLOGY: AUTOMATED STOWAGE AND RETRIEVAL SYSTEM

<u>Description</u>: Marinization of an existing COTS technology Automated Stowage and Retrieval System that is produced commercially by Seimans Dematic. The ASRS system would automate storerooms, holds and magazines and would allow for selective offload of pallet sized laods. Loads would automatically be locked into stowage during Strike-Down and unlocked for Strike-Up.

Team:

- General Dynamics Armament and Technical Products
- Siemans Dematic
- NAVSEA Philadelphia, Code 973
- Bath Iron Works

<u>Deliverables</u>: The key deliverable was a final report that describes the utility of the equipment and a strategy for future development efforts.

<u>Demonstrations</u>: A non-physics-based simulation of the application of such a system in combination with other cargo handling advancements was developed.

<u>Future Efforts</u>: The key future effort for this technology would be to develop and demonstrate a functional system on a ship motion simulator.



COTS System



Future Automated Hold

TECHNOLOGY: BLAST RESISTANT CONTAINERS

<u>Description</u>: Lightweight composite material and manufacturing processes for new generation ordnance containers to contain the effects of accidental ignition of the contents. The containers would hold fuzes and other sensitive initiators that could then be stowed with the actual weapons.

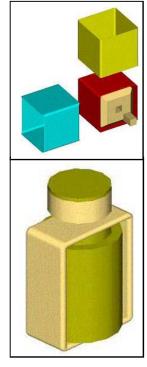
Team:

- NSWC-IH Detachment Earle PHS&T Center
- NSWC Indian Head
- Honeywell

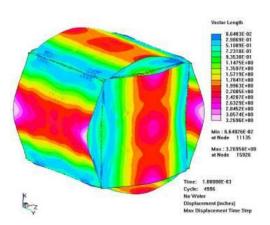
<u>Deliverables</u>: The key deliverable was a final report that describes the results of the analytical efforts to model the container and the blast effects.

<u>Demonstrations</u>: No equipment was tested during this effort, however it leveraged off of previous demonstration by Honeywell.

<u>Future Efforts</u>: The key future effort for this technology would be to test representative containers and use those tests to validate both the concept and the underlying modeling, which would provide higher confidence for future virtual prototyping.



Potential Container Configurations



Response Under Blast Conditions